



# AEC-NASA TECH BRIEF



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## Instabilities Encountered During Heat Transfer to a Supercritical Fluid

An investigation has been made of the unstable behavior of a heat-transfer loop operating at a supercritical pressure.

In recent years, studies of heat transfer to fluids near their critical point have revealed that severe pressure and flow oscillations spontaneously accompany the transfer of heat in this region. Since no plausible explanation has been advanced, the purpose of this study was to investigate this unstable behavior, which occurs in connection with the transfer of heat to a fluid near its thermodynamic critical point.

The instabilities were studied in a heat transfer loop designed to operate by either natural or forced convection. Since the instabilities were strongly damped during forced-convection, attention was concentrated on natural convection operation.

Two types of oscillatory behavior, acoustic and slow, were observed during the tests. Pressure and flow oscillations occurred with bulk temperatures below the pseudocritical temperature and with heater wall temperatures exceeding the pseudocritical temperature. The basic cause of both types of oscillatory behavior appeared to originate in the heated boundary layer.

The first type of oscillation was of an acoustic nature, exhibiting harmonic pressure and flow oscillations in the range of 5 to 30 cps. The acoustic oscillations are believed to have been initiated by a local disturbance, which resulted in pressure waves being propagated at sonic speed away from the disturbance. For the oscillation to have been maintained, the acoustic pressure wave would have to be reinforced upon passing a given point in the system. A mechanism that would cause the acoustic pressure wave to be reinforced is postulated in the report.

When the outlet bulk temperature was slightly below the pseudocritical temperature, a different type of oscillation was observed. This oscillation was characterized by a frequency two orders of magnitude slower than the sonic oscillations. The frequency of the acoustic oscillations decreased with temperature, while the frequency of the slow type increased with temperature.

The data indicates that this type of oscillation was initiated and sustained by a sudden improvement of the heat transfer coefficient, which attributed to the occurrence of a "boilinglike" phenomenon in the supercritical fluid. An approximate numerical solution, which closely matched the experimentally observed results during the slow oscillations, verified the importance of the heat transfer improvement in triggering and maintaining the oscillations.

Both the acoustic and slow oscillations also occur during subcritical boiling heat transfer. Generally, the acoustic type has been considered of secondary interest, but a large amount of attention has been focused on the slow type due to its importance in nuclear reactor applications.

### Notes:

1. These results are reported in "An Investigation of Instabilities Encountered During Heat Transfer to a Supercritical Fluid", by A. J. Cornelius of Argonne National Laboratory, ANL-7032, April 1965. This report is available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151; Price-\$3.00 (microfiche \$0.65).
2. The report includes the experimental apparatus and procedure used, the experimental results, and an analysis of slow oscillations.

(continued overleaf)

3. Inquiries concerning this report may be directed to:

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Reference: B69-10042

Source: A. J. Cornelius  
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(ARG-10266)

**Patent status:**

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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